CATALOGUE

OF THE

ILLUSTRATIONS OF THE WATER-SUPPLY

OF THE

CITY OF NEW YORK.

WRITTEN FOR THE

BOARD OF GENERAL MANAGERS

OF THE

EXHIBIT OF THE STATE OF NEW YORK

AT THE

WORLD'S COLUMBIAN EXPOSITION

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PREFACE.

THE writer was requested, about four months ago, by the Hon. Donald McNaughton, Chief Executive Officer of the Board of General Managers of the Exhibit of the State of New York at the World's Columbian Exposition, to prepare an exhibit for this Exposition, consisting of photographs, lithographs, etc., to illustrate the water-supply of the city of New York. To have presented this exhibit without some words of explanation would have been unsatisfactory; and this catalogue, which contains some statistics of the water-works of New York, and explains the photographs, etc., in a general way, was therefore written. It would require a large volume to describe the works in detail.

For the information of visitors at the World's Columbian Exposition who may take more than a casual interest in this subject the writer will state

that he has in preparation a work on the Water-supply of the City of New York, soon to be published, which will give full information about all the details of the works.

E. WEGMANN, Jr.

KATONAH, N. Y., June 26, 1893.

INTRODUCTION.

THE city of New York is supplied with water by means of the following three aqueducts:

Name.	When Constructed.	Maximum Discharge in 24 hours.
		U. S. Gallons.
The Old Croton Aqueduct . .	1837–1843	95,000,000
The New Croton Aqueduct .	1884–1893	300,000,000
The Bronx River Conduit . .	1880–1885	28,000,000
Maximum Discharging Capacity per day.		423,000,000

The first two of the aqueducts mentioned above bring a supply from the Croton water-shed; the last, from the basin of the Bronx River.

The minimum daily supply which can be obtained from these water-sheds, by collecting all the available water into storage-reservoirs, is estimated as follows :

Name.	Area.	Minimum Average Daily Supply.
Croton Water-sheds	339 square miles above the old Croton Dam.	250,000,000
Bronx Water-sheds	13 square miles. . .	13,000,000
Total		263,000,000

To obtain the full supply which may be derived from these water-sheds, many large reservoirs are required in which the surplus water in times of floods can be stored for periods of drought.

The table on the following page gives the reservoirs that have been constructed for this purpose up to January 1st, 1893.

In addition to the water stored in the reservoirs mentioned, the city of New York has a large reserve of water in the numerous lakes and ponds in the Croton water-shed, from which it draws water in seasons of drought, in accordance with permanent or temporarily acquired rights.

During the drought of 1880, 2,116,000,000 U. S. Gallons of water was obtained in this manner by the city from twelve lakes and ponds.

New reservoirs are being constructed as indicated in the table on page 8.

PRESENT RESERVOIRS.

Name.	Constructed.	Capacity.
For the Croton Aqueducts.		U. S. Gallons.
Croton Lake	1837–1842	600,000,000
Old Receiving Reservoir in Central Park	1839–1842	180,000,000
New Receiving Reservoir in Central Park.	1858–1863	1,000,000,000
Distributing Reservoir at 42d Street	1839–1842	24,000,000
Boyd's Corner Reservoir on West Branch of Croton River	1866–1873	2,700,000,000
High Bridge Reservoir. . . .	1866–1873	10,000,000
Middle Branch Reservoir . . .	1874–1879	4,000,000,000
Double Reservoir "I," on East Branch of Croton River . .	1888–1893	9,500,000,000
For the Bronx Conduit.		
The Rye Ponds	1880–1885	1,050,000,000
Kensico Reservoir	1880–1885	1,620,000,000
Williamsbridge Receiving Reservoir	1884–1890	120,000,000
Total		20,804,000,000

The Aqueduct Commissioners have decided to construct a distributing reservoir of about 1,500,000,000 gallons capacity at Jerome Park, in the Annexed District. The plans for this work are now being prepared.

The Department of Public Works has commenced

RESERVOIRS IN CONSTRUCTION.

Name.	Commenced.	Capacity.
Amawalk Reservoir . . .	1889	5,200,000,000
Titicus " . . .	1890	6,000,000,000
Carmel " . . .	1890	9,000,000,000
New Croton " . . .	1892	30,000,000,000
Byram Pond " . . .	1893	550,000,000
Byram " . . .	1893	180,000,000
Total		50,930,000,000

the work of joining the Bronx and Byram River water-sheds by a tunnel, which will add about 5,000,000 gallons per day to the city's water-supply.

The principal facts of the growth of the water-works are given in the following brief history of the water-supply of the city of New York:

The early inhabitants of Manhattan Island obtained their supply of water from shallow wells by means of buckets and pumps.

As the population of the Island increased, these wells became soon so polluted as to be unfit for domestic use. The supply obtained in this primitive manner was also found to be inadequate for the needs of the people.

In 1774, when New York had a population of

about 22,000, Mr. Christopher Colles made a proposition to the Common Council, for constructing public water-works which was accepted.

The works were constructed accordingly. They consisted of a reservoir on the east side of Broadway, between Pearl and White Streets; of a large well near the "Collect" (a large fresh-water pond occupying the space where now stand the Tombs and the surrounding blocks); of a steam-engine for pumping the water from the well to the reservoir; and of a system of distributing pipes, consisting of hollow logs.

The works were put into operation in 1776, but were soon abandoned, owing to the confusion caused by the Revolution.

After the restoration of peace, the question of obtaining a water-supply for the city was agitated from time to time, but no practical measures were taken in this direction until April, 1799, when the Manhattan Water Company was incorporated, with a capital stock of $2,000,000, to supply the city of New York "with pure and wholesome water."

The Manhattan Water Company sunk a well, 25 feet in diameter, in Duane Street, near Centre Street, in a thickly populated part of the city, and pumped

water by steam-engines into a reservoir constructed on Chambers Street, from which it was distributed through hollow logs laid in some of the principal streets. The supply was, however, neither ample nor pure. A great many schemes for obtaining a satisfactory water-supply were, therefore, proposed by citizens of New York from time to time.

The necessity of having an ample water-supply was especially felt in cases of fire. In 1829 the Common Council had a small reservoir constructed on 13th Street, on the line of Irving Place, solely for storing water for extinguishing fires.

The reservoir consisted of an iron tank, 44 feet in diameter and 20½ feet high, containing 233,169 gallons, which was placed in an octagonal building. It was filled by means of steam-pumps from a well 16 feet in diameter and 112 feet deep. The water was distributed through two lines of 12-inch cast-iron pipes, one laid in Broadway and the other in the Bowery.

This reservoir was the beginning of the public water-works of the City of New York.

In response to repeated petitions from the Common Council of the City of New York, the State Legislature passed an Act, on February 25th, 1833, author-

izing the Governor, with the consent of the Senate, to appoint five Commissioners, who were to make a thorough investigation of the best means of obtaining an ample supply of pure water for the city of New York.

The Commissioners were appointed at once, and reported, after a year's investigation, to the Common Council and to the Legislature that, in their opinion, the Croton River was the only source from which the city could obtain an adequate supply of pure water at a reasonable cost.

On May 2d, 1834, the Legislature of the State of New York passed "An Act to provide for supplying the City of New York with pure and wholesome water."

This Act provided that the Governor should appoint, with the consent of the Senate, five Water Commissioners, who should prepare plans for a water-supply for the city of New York, and should report the same to the Common Council.

If this body approved of the plans, the question as to whether they were to be carried out or not was to be submitted to a vote of the citizens.

Under this Act the Governor appointed the same gentlemen Commissioners who had investigated the

question of the water-supply under the Act of the previous year.

With the assistance of their Chief Engineer, Major D. B. Douglas, the Water Commissioners perfected plans for a supply from the Croton River, which were approved by the citizens in a vote taken on April 14th, 15th, and 16th, 1835.

The Croton Aqueduct and Reservoirs (known now as the old works in distinction to those constructed since 1883) were constructed under the direction of the Water Commissioners, Mr. J. B. Jervis being Chief Engineer, in 1837 to 1843.

The water was allowed to flow through the Aqueduct, from Croton Lake (the fountain reservoir) to the 42d Street reservoir, for the first time on July 4th, 1842.

At this time the works were practically finished, with the exception of the "High Bridge" across the Harlem River, which was not completed until November, 1848. The water was conveyed temporarily across the Harlem River in a 36-inch cast-iron pipe, laid on an embankment.

Five Water Commissioners, appointed under the Act of May 2d, 1834, continued to have charge of the water-works of the city, with the exception of the lay-

ing of distributing pipes, which work was performed under the direction of a committee of the Common Council, until the Legislature passed, on April 11th, 1849, an Act organizing "the Croton Aqueduct Department."

Under this Act the maintenance and extension of the water-works of the city were intrusted to a Board of three Commissioners, one of whom was to be a Civil Engineer. They were to be appointed by the Mayor of the city, with the approval of the Common Council.

Mr. Alfred W. Craven was appointed as the Engineer Commissioner, and held this position for about twenty years, until he resigned in 1868. He was succeeded by General George S. Greene.

The Croton Aqueduct Department had charge of the city's water-works until it was superseded by the Department of Public Works, organized under an Act of the Legislature in April, 1870.

The works were extended by the Croton Aqueduct Department as follows:

A large receiving reservoir, having a capacity of 1,000,000,000 U. S. gallons, was constructed in Central Park (1858–1863).

An additional pipe, 90½ inches in diameter, made

of wrought-iron plates, was laid across "High Bridge," which was raised about 6 feet (1860–64).

The Aqueduct between 86th and 92d streets, which interfered with the grading of the streets, was torn down and replaced by two lines of cast-iron pipe 6 feet in diameter (1865–1868).

The construction of a high-service reservoir and tower was commenced in 1866 but was not completed by April, 1870.

The construction of an additional storage reservoir on the West Branch of the Croton River at Boyd's Corner was also commenced in 1866, but not finished by April, 1870.

In addition to the above, the Croton Aqueduct Department had a great many large mains and distributing-pipes laid.

The Department of Public Works has had charge of the city's water-works from April, 1870, to the present time.

The whole work of this Department is entrusted to one Commissioner, who is appointed by the Mayor alone, the consent of the Common Council not being required.

The first person who held this responsible position was Wm. M. Tweed.

The present Commissioner of Public Works is Hon. Michael T. Daly. The engineers in charge of the water-works are :

Mr. George W. Birdsall, Chief Engineer; Mr. John E. McKay, First Assistant Engineer.

The Department of Public Works completed the work commenced by the Croton Aqueduct Department, and improved and extended the water-works as follows :

The Aqueduct from 92d to 113th Street was removed, as it interfered with the grading of the cross streets, and replaced by 6 lines of 48-inch pipes, laid below the surface of the street in 10th Avenue (1870–1877).

A new storage reservoir, having a capacity of 4,000,000,000 U. S. gallons was constructed on the Middle Branch of the Croton River (1874–1879).

According to the original plans, the Aqueduct was not to be filled above the spring-line of the arch, its maximum discharge being estimated at 72,000,000 U. S. gallons in 24 hours. The Department had the upper part of the conduit strengthened (commencing in 1875) so as to be able to raise the level of the water to 12 inches from the crown of the arch. This increased the discharge to 95,000,000 U. S. gallons per day.

An additional supply of water of about 15,000,000 U. S. gallons was obtained from the Bronx River (1880–85). The water was stored in the Rye Ponds, and in a reservoir constructed at Kensico.

It was conveyed to a distributing reservoir at Williamsbridge, in the Annexed District.

This system is being extended since 1889 so as to obtain an additional supply of about 5,000,000 U. S. gallons from the Byram River, the water being stored in Byram Pond and Byram Reservoir.

New high-service works were constructed at 98th Street and 9th Avenue (1879–1881).

A new storage reservoir having a capacity of 5,211,-000,000 U. S. gallons is now being constructed by the Department of Public Works on the Muscoot River, in the Croton water-shed. Ground was broken in December, 1889. The contractor of the work is Mr. John McQuade. Col. John Meachan is the engineer in immediate charge of the work.

The Croton water-shed, containing 339 square miles above the present Croton Dam and 360 square miles above the site of the proposed New Croton Dam, is estimated to supply a minimum quantity of about 250,000,000 U. S. gallons per day. Of this

quantity less than 100,000,000 gallons can be discharged by the Old Croton Aqueduct.

As the daily consumption of water has been for many years about 100 gallons per capita in New York, owing to great waste and extravagance in its use, the need of another aqueduct from the Croton Valley was felt from the time the Old Aqueduct had reached its maximum discharge (about 1873).

Surveys for a new aqueduct from the Croton Valley, having a capacity of discharging 150,000,000 U. S. gallons per day, were made in 1875, during the administration of Gen. Fitz-John Porter as Commissioner of Public Works.

The financial condition of the city being at the time in a deplorable condition, owing to maladministration during the reign of the Tweed ring, the work of constructing a new aqueduct from the Croton Valley could not be undertaken.

As a temporary expedient a supply of about 15,000,000 gallons per day was obtained from the Bronx River (1880–1885) during the administration of Mr. Allan Campbell as Commissioner of Public Works.

The necessity of obtaining an additional water-supply for the city of New York continued, however,

to make itself felt. The danger of depending on only one aqueduct, which was being severely strained to meet the demand for water, was also apparent.

The city's finances having recovered from the disorder into which they had been brought by the Tweed ring, the Legislature created, by Chapter 490 of the Laws of 1883, the Aqueduct Commission, which was to be intrusted with the construction of a new aqueduct from the Croton Valley, with the necessary reservoirs and appurtenances.

The Aqueduct Commission was organized in August, 1883, and proceeded at once to carry out its work. Under its direction a new aqueduct, capable of discharging 300,000,000 U. S. gallons per day, has been constructed (1884–1893), and also a large storage reservoir on the east branch of the Croton River, known as the Double Reservoir I (consisting of the Sodom Reservoir and the Bog Brook Reservoir), having a storage capacity of 9,500,000,000 U. S. gallons.

Additional storage reservoirs are being constructed at present under the direction of the Aqueduct Commissioners, as follows:

		Capacity in U. S. Gallons.
Titicus Reservoir	. . . .	6,000,000,000
Carmel "	. . . .	9,000,000,000
New Croton "	. . . .	30,000,000,000
		45,000,000,000

A new distributing reservoir, having a capacity of about 1,500,000,000 U. S. gallons, is soon to be constructed at Jerome Park in the Annexed District.

The composition of the Aqueduct Commission has been changed by several laws. The present Aqueduct Commissioners are:

Thomas F. Gilroy,	Mayor.
Theodore W. Myers,	Comptroller,
Michael T. Daly,	Commissioner of Public Works.
General James C. Duane.	President.
J. J. Tucker,	Vice-President.
Francis M. Scott,	Commissioner.
H. W. Cannon,	Commissioner.

Mr. B. S. Church was the Chief Engineer of the Aqueduct Commission from August 15th, 1883, to November 21st, 1888, when he resigned. He was succeeded by Mr. A. Fteley, the present Chief Engineer, who had been connected with the works since the beginning as Deputy Chief Engineer.

THE OLD CROTON AQUEDUCT.

(*CONSTRUCTED* 1837-1843.)

THE OLD CROTON AQUEDUCT.

(Constructed 1837–1843.)

Length, from Croton Lake to 42d Street Reservoir, 40.56 miles. General grade, 1.109 feet per mile. Area of cross-section of water channel, 53.34 square feet. Maximum discharge, 95,000,000 U. S. gallons. Cost of Aqueduct and reservoirs, not including distributing pipes nor interest on water stock, about $9,000,000.

The water flowed through the whole Aqueduct, for the first time, on July 4th, 1842. The works were practically finished at that time, with the exception of the "High Bridge" across the Harlem River, which was not completed until November, 1848.

The works were constructed under the direction of a Board of five Water Commissioners, appointed under the Act of May 2d, 1834.

The preliminary plans were prepared by Major D.

B. Douglas, who was Chief Engineer from June 5th, 1833, to October 11th, 1836.

Mr. J. B. Jervis had charge of the construction of the works, as Chief Engineer from October 11th, 1836, to April 11th, 1849.

Photograph 1*a*. Croton Dam during a drought, no water passing over its crest. During severe freshets a body of water 8 feet deep has flowed over the dam.

The main part of the dam consists of a masonry structure, about 50 feet high above the foundation and 290 feet long. An earthen bank, having a slope of 5 to 1, was placed against its up-stream face. Near the north bank of the river the dam was constructed entirely of earth.

1*b*. Croton Lake, a storage reservoir formed by Croton Dam.

It has an area of 400 acres and a storage capacity of 600,000,000 U. S. gallons.

2. Aqueduct Bridge across Sing Sing Kill, in the village of Sing Sing. The Aqueduct has here a height of 82 feet above the rock foundation. The span of the stone arch is 88 feet.

To insure water-tightness at this bridge the masonry conduit was provided with a lining of cast-iron plates which was built inside of the brickwork.

3a. Aqueduct Bridge, across a highway near Tarrytown.

3b. Aqueduct at Yonkers, 40 feet high. The two arch culverts, of 25 feet span, form a passage for the Sawmill River.

4a. High Bridge, looking North. This bridge was constructed in 1839–1849 to carry the Aqueduct across the valley of the Harlem River. It consists of a series of 15 semicircular arches, 8 having spans of 80 feet and 7 of 50 feet, and of two abutments. The height of the intrados of the arches at the crown is 100 feet above high tide. It is 1450 feet long and about 25 feet wide.

The original cost of the bridge was $963,428.

At first only two 36-inch cast-iron pipes, having a capacity of discharging about 30,000,000 gallons per day, were laid across the bridge and covered with earth. This was soon found to be insufficient.

In 1860–1864 the Croton Aqueduct Department constructed a wrought-iron pipe, 90½ inches in diameter, on top of the bridge, raised the side walls of the bridge and built a brick arch over the pipe, forming thus a vault.

4b. High Bridge, looking west. Shows the high-service tower and the pumping station on the west

side of the bridge, at which water from the Aqueduct is pumped into the tower and high-service reservoir.

5. High-service Reservoir and Tower, constructed 1866–1873.

The capacity of the reservoir is 10,794,000 U. S. gallons. The tower is about 170 feet high. An iron tank, holding 47,000 U. S. gallons, is constructed in the upper part of the tower. The highest level of the water in the tank is 324 feet above high tide, which is 57 feet above the highest point on Manhattan Island. The maximum depth of the water is 16 feet.

The bottom of the reservoir is 200 feet above high tide.

The reservoir and the tank in the tower are filled with water from the Aqueduct by means of steam-engines, placed in an engine-house near the west end of High Bridge.

6. High-service Tower at 98th Street and 9th Avenue; constructed 1879–1881. A stand-pipe, 6 feet in diameter and about 170 feet high, constructed of wrought-iron plates, was placed inside of the tower.

7. Two views of the Worthington pumping-engines of the 98th Street high-service works.

The three engines at this station were all built by Henry R. Worthington of New York. Two of these engines were ordered in 1879, and are known as the Worthington horizontal low-duty pumping-engines. The other engine was ordered in 1890, and is known as the Worthington horizontal high-duty engine.

The two low-duty engines are duplicates, and each have two high-pressure cylinders 19¼ inches in diameter, two low-pressure cylinders 33⅜ inches in diameter, and two double-acting water-plungers 26 inches in diameter, all of 48 inches stroke. These two engines have each four single-acting air-pumps, two of which are 17 inches in diameter and two 18¾ inches in diameter, all of 20 inches stroke, which are operated by beams which are driven from the main cross-heads. Each of these engines have a capacity of seven and one-half million gallons in twenty-four hours, against a total head of about 100 feet.

The high-duty engine has two high pressure cylinders 18 inches in diameter, two low-pressure cylinders 36 inches in diameter, and two double-acting water-plungers 26 inches in diameter, all of 36 inches stroke. This engine has a surface-condenser located in the engine suction-pipe, and the condensed steam is removed from the condenser by means of a

small independent air-pump. This engine has cut-off valves on all steam-cylinders, and the steam is worked expansively by means of the well-known Worthington High-duty Attachment. This engine has a capacity of 10,000,000 United States gallons in twenty-four hours against a head of 100 feet.

8*a*. Junction Gate-house at 92d Street and 9th Avenue, constructed 1860–1863, in connection with the new large receiving reservoir in Central Park. By means of sluice-gates placed in this gate-house the water flowing in the Old Aqueduct can be turned either into the old or the new receiving reservoir.

The second gate-house, shown in the background of the picture, was constructed in 1872–1877 to control the outlet of the six lines of 48-inch cast-iron pipes which were substituted for the Old Aqueduct between 92d and 113th streets (see page 15).

8*b*. North Gate-house of the new receiving reservoir in Central Park. The flow of water from the Aqueduct into the reservoir is controlled by gates placed in this gate-house. It also serves as an outlet through four 36-inch distributing pipes, of which, however, only two have been laid thus far.

9*a*. The new Central Park Receiving Reservoir, looking west; shows new and old gate-house at

north end of reservoir and the 98th Street pumping-station in the distance. Area of reservoir, 96 acres; storage capacity, 1,030,000 U. S. gallons; maximum depth of water, 38 feet.

A central wall divides the reservoir into two parts, either of which can be emptied independently of the other.

9b. The Distributing Reservoir at 42d Street, the terminus of the Old Croton Aqueduct. It was constructed in 1839–1843, on what was known as Murray Hill, to insure a good head of water at the point of distribution, near the city. This basin, which has an area of about four acres and a storage capacity of 24,000,000 U. S. gallons, was formed by means of embankments of puddled earth, which were supported on the outside by masonry walls. The walls were made hollow to obtain a greater breadth with a given amount of masonry, and also to facilitate the inspection of the water-tightness of the reservoir. On the water side the embankments were faced with hydraulic masonry 15 inches thick.

An Act passed by the last Legislature of the State of New York has ordered the removal of the 42d Street Reservoir, which is no longer considered an essential part of the water-works.

10. Old Croton Aqueduct near 100th Street. When the Old Aqueduct was constructed, Manhattan Island above 86th Street consisted only of farm-land. From 86th to 113th Street the masonry conduit was constructed on a high embankment. As the city grew, and cross-streets had to be graded in this region, the Aqueduct was found to be a serious obstruction. It was therefore removed, and replaced by iron pipes laid below the surface of the ground. This work was performed in 1865–1868 from 86th to 92d Street, and in 1870–1877 from 92d to 113th Street.

11. Another view of the ruins of the Old Aqueduct, where it had been torn down on account of the grading of new streets.

THE BRONX RIVER WORKS.

(*CONSTRUCTED* 1880–1885.)

THE BRONX RIVER WORKS.

(Constructed 1880–1885.)

12*a*. Front view of Kensico Dam.

12*b*. Rear view of Kensico Dam.

This dam forms a storage reservoir of 1,050,000,000 U. S. gallons capacity. A line of 48-inch cast-iron pipes conveys the water to a distributing reservoir, located at Williamsbridge, in the Annexed District.

13–16. Show some of the work constructed in connection with the Kensico Reservoir.

CONSTRUCTION OF
THE NEW CROTON AQUEDUCT.

(1884–1893.)

CONSTRUCTION OF THE NEW CROTON AQUEDUCT.

(1884–1893.)

Length of Aqueduct (Croton Lake to Central Park Reservoir), 33.12 miles.

Discharging capacity to proposed distributing reservoir at Jerome Park, 300,000,000 U. S. gallons in 24 hours.

Discharging capacity from Jerome Park to Central Park Reservoir, 250,000,000 U. S. gallons in 24 hours.

Cost of Aqueduct (Croton Lake to Central Park Reservoir), not including reservoirs nor interest on water stock, $24,755,341.20.

16. Two views of the large Inlet Gate-house at Croton Lake; cost $734,381.57.

This gate-house was constructed on high ground, as Croton Lake is to be raised by the new Croton

Dam about 28 feet. The gate-house has four inlets from the lake, placed at different elevations, the object being to produce circulation in the lake by changing from time to time the point of inlet.

17*a*. Pocantico Blow-off Gate-house. At five points on the Aqueduct the water can be discharged into a brook or river with a view of emptying the conduit either partially or entirely. In the former case, the part of the Aqueduct which is to be emptied is separated from the other parts by means of temporary wooden dams, which are formed by "stop-planks" placed across the conduit in grooves cut in the masonry of some of the blow-off gate-houses.

The blow-off gate-houses are located at the following points:

Pocantico;
Ardsley;
South Yonkers;
Shaft 24, at the Harlem River;
Shaft 25, at the Harlem River.

The picture shows the blow-off culvert, and the manner in which the Pocantico River is carried over the top of the Aqueduct.

17*b*. The Pocantico Blow-off Culvert, seen through

the opening of a stone and highway bridge, built at "Sleepy Hollow."

18. Views taken respectively at the sites of Shafts 9 and 10, showing the compressor-house, head-house, etc.

19*a*. Shows the manner in which the headings were generally driven, viz., by four percussion-drills, two mounted on the same vertical column.

19*b*. Photograph taken in the "heading" after a blast.

20*a*. Shows the manner in which the masonry was laid in the open cuts. The side walls and invert consisted generally of rubble masonry, lined with brickwork. The arch was made of brickwork 12 to 24 inches thick, according to circumstances.

20*b*. The Aqueduct passes under the Sawmill River. The excavation was made in open trench, the river having been turned into a new channel. This piece of work was very difficult, owing to the clayey nature of the earth and the width of the trench, 27 feet.

21. The Aqueduct had to be constructed, near Tarrytown, under a swamp belonging to the late Mr. Jay Gould. An attempt was made to excavate through the soft material, but this work had to be

abandoned. The Aqueduct was finally depressed at this point sufficiently to bring the tunnel excavation into solid rock, and forms here, therefore, an inverted siphon.

22a. Aqueduct Trench near Ardsley, illustrating the manner in which the masonry was laid.

22b. Blow-off Gate-house at Ardsley, in course of construction. The object of the central pier is to reduce the span of the stop-planks, which are put across the Aqueduct to form a dam when part of the conduit has to be emptied.

23a. Shows the Façade of the Culvert of the Blow-off Gate-house at Ardsley.

23b. Soft ground was encountered in the tunnel driven south from Shaft 17. The heavy timber bulk-head, shown in the picture, was constructed to keep back the soft material, but in spite of its strength gave way under the great pressure it had to support, causing the death of some of the workmen.

24. Illustrates the method employed to sustain the roof of the tunnel, when it was found to be insecure, until the masonry could be laid.

25. Two views of the Blow-off Gate-house at South Yonkers.

26. Two views of the South Yonkers Blow-off Gate-

house, in course of construction. Shows the general arrangement of the Pocantico, Ardsley, and South Yonkers blow-offs, which is as follows:

The gate-house is built on the line of the Aqueduct. A central pier divides the water flowing in the conduit into two streams. This pier and the side walls of the gate-house opposite it have grooves which are cut in the masonry. By dropping stop-planks into these grooves a dam can be quickly formed across the Aqueduct. Sluice-gates, placed at right angles to the line of the Aqueduct, serve to discharge the water from one side of the dam of stop-planks.

The gate-house is also provided with an overfall-weir, constructed in connection with the sluices, which prevents the water in the conduit from rising above a fixed height.

27*a*. Excavating the Aqueduct Trench at the Pocantico Cut. Maximum depth of excavation about 40 feet.

27*b*. Building the Side Walls in the Pocantico Cut.

28. Two views of the Aqueduct Trench near the South Yonkers Gate-house, illustrating the manner in which the construction was carried on.

29. Shows the Head-house at Shaft 20, the engineers, workmen, etc.

30*a*. A general view of the Blow-off Vault at Shaft 24, on the east side of the Harlem River.

30*b*. Sinking Shaft 24.

31*a*. Shows the location of Shaft 25, on the west side of the Harlem River; the drift made for a "blow-off," to discharge the water through two 48-inch pipes into the Harlem River; the incline, which served for transporting building material during the construction of the work, etc.

The Aqueduct tunnel which was excavated under the Harlem River, about 300 feet below high-water, was driven entirely from Shaft 25.

31*b*. Sinking Shaft 25, showing the derrick and bucket used for removing the material excavated. This shaft is the largest and deepest shaft on the New Aqueduct. It was excavated to a rectangular cross-section 16.5 feet by 33 feet, inside of timbers, and sunk to a depth of 426 feet below the surface of the bluff on which it was located. It was built up with masonry, so as to contain two circular wells, 12′ 3″ in diameter, one for the Aqueduct and the other for a pump-well for emptying the siphon under the Harlem River, whenever it should be necessary for inspection, etc.

The tunnel under the river is emptied by means of

two wrought-iron buckets, each containing about 1300 gallons, which are moved up and down in the pump-well by a large steam-engine placed in a masonry head-house at Shaft 25. The buckets discharge their contents automatically into one of the blow-off pipes.

32*a*. After Shaft 25 had been sunk, the derrick and bucket (shown in picture 31*b*) were replaced by a timber head-house and by "cages" (elevators), manufactured by the Otis Elevator Company.

32*b*. Shows the cast-iron lining rings, 12′ 3″ in diameter and $1\frac{1}{4}$–$1\frac{1}{2}$″ thick, which were placed in the pump-well and at places in the Aqueduct well of Shaft 25, to insure water-tightness.

33*a*. Blow-off Gate-house of Shaft 25. Serves to empty the "Aqueduct under pressure" (Jerome Park to 135th Street Gate-house) into the Harlem River by means of two 48-inch blow-off pipes, each provided, as a matter of safety, with two 48-inch stop-cocks.

33*b*. A view taken in Shaft 26 while it was being sunk.

34. Head-house of Shaft 26. This shaft is the point of "overflow" on Manhattan Island. It is 12′ 3″ in diameter, and is provided at the top with an overflow-weir, the height of which can be regulated by means of stop-planks. Whenever the water

in the shaft rises above the top of the weir it flows off into the Harlem River through two lines of 48-inch overflow-pipes.

The upper part of the shaft where the weir is constructed was excavated in open trench.

35*a*. Temporary timber Head-house of Shaft 29, in the middle of 10th Avenue near 157th Street. After crossing the Harlem River the Aqueduct is continued in tunnel, about 100–150 feet below the surface of the streets, to the 135th Street Gate-house, where the pipe-lines commence. From 178th to 152d Street this tunnel is located under 10th Avenue. The picture shows how the shaft, which had to be sunk between the tracks of the 10th Avenue Cable Road, was operated.

After the work was finished, a 48-inch manhole pipe was built in the masonry of the shaft and covered with a cast-iron plate placed beneath the paving of the street, which was restored to its former condition.

35*b*. Shows one of the Portals of the Aqueduct Tunnel.

36. Cast-iron lining for the Aqueduct near Shaft 30. About 400 feet south of this shaft soft ground was encountered, and the roof of the tunnel finally caved in. As the water in the Aqueduct tunnel

would rise above the surface of the street if it were not confined, it was decided to place a cast-iron lining inside of the brickwork for about 200 lineal feet, at the place in question, in order to make the conduit perfectly water-tight. The picture shows one of the lining-rings put together on the surface near the shaft.

37*a*. For a distance of about 6½ miles (Jerome Park to 135th Street Gate-house) the Aqueduct forms an inverted siphon, and is therefore under pressure. It is made circular, 12′ 3″ in diameter, with the exception of the tunnel under the Harlem River, which was made only 10′ 6″ in diameter to reduce the area of the excavation in ground which was known by the preliminary borings to be treacherous.

37*b*. Shows the scaffolding on which the drills were mounted for "trimming" the upper parts of the tunnel excavation.

38*a*. The Gate-house at 135th Street forms the junction of the Old and the New Aqueduct. Twelve lines of 48-inch cast-iron mains convey the water from the Gate-house to the city, eight being laid in Convent Avenue in connection with the new works and four joining the old mains on 10th Avenue. The outlet through each line of pipes is controlled in the gate-

house by a sluice-gate and by a stop-cock. Should both of these means fail, the outlet through any one of the twelve lines of pipe can be stopped by stop-planks placed in grooves cut in the masonry.

38*b* and 39 show the Gate-house at 135th Street in course of construction.

40. The Central Park Gate-house. Four of the eight lines of 48-inch mains laid from the 135th Street Gate-house down Convent Avenue terminate in this Gate-house, which was constructed at the north end of the large reservoir in Central Park.

41. Shows the manner in which the drills manufactured by the Ingersoll Drill Company were used for driving a heading and for sinking a shaft.

42. Shows the two kinds of drills manufactured by this company, and also one of their air-compressors.

43 and 44. The Air-compressors and Drills manufactured by the Rand Drill Company.

Almost the whole Aqueduct tunnel, 30 miles long, was driven by means of the drills and compressors made by the Ingersoll Drill Co. and the Rand Drill Co. Some Norwalk Air-compressors were also used, and on Section 7 the Rattler Drills invented by Professor J. E. Denton.

45 and 46 Show the current meter, by means of

which the average velocity in the Aqueduct was determined.

47*a*. Pipe-line on Convent Avenue, laid in connection with the new works. Of the eight lines of 48-inch pipe, four were laid to the Central Park Reservoir and the other four connected directly with the distributing pipes.

47*b*. Five of the new lines of 48-inch mains were laid on the east side of 8th Avenue from 106th to 100th Street, under the sidewalk.

48. The four lines of 48-inch mains, which were to terminate at the large reservoir in Central Park, were laid in the Transverse Road which enters the Park at 97th Street.

49*b*. Pipe-line on 8th Avenue.

50. Shows the manner of "pouring a joint." Each joint of the 48-inch mains required 150 to 160 lbs. of lead, which was poured in one operation.

51*a*. Shows the site of the East Branch Reservoir, known as the "Double Reservoir I." It consists of two basins—the Sodom Reservoir and the Bog Brook Reservoir—which are connected by a tunnel 2000 ft. long and 10 ft. in diameter. While these two basins have about equal storage capacities, the watershed of the former is about twenty times as large as

that of the latter, the water-sheds containing respectively 73 42 and 3.5 square miles. The tunnel permits the waste-water of the larger basin (Sodom Reservoir) to fill the smaller one.

The whole storage capacity of the East Branch Reservoir is about 9,500,000,000 U. S. gallons.

51*b*. The Bog Brook Reservoir, constructed in 1889–1893, under the direction of the Aqueduct Commissioners, at a cost of about $332,000. It has an area of 394 acres and a storage capacity of about 4,000,000,000 U. S. gallons.

52, 53, and 54 illustrate the construction of the Sodom Dam, built in 1888–1893 for the Aqueduct Commissioners by Sullivan, Rider & Dougherty, contractors. Final amount paid the contractors, $436,-499.05. Area of Sodom Reservoir, 534 acres; storage capacity, about 5,500,000 U. S. gallons.

The Sodom Dam was built of masonry, and has proved to be absolutely water-tight. It has a length of 500 ft. at the coping, and a maximum height of 98 ft. above the foundation.

An interesting feature in the construction of the work was the use of a steel cable (2 inches in diameter, stretched over two towers 667 feet apart and anchored to the rock), which served by means of a

trolley, operated by a steam-engine placed at one of the towers, for delivering the building materials on the wall.

The water is discharged from the reservoir into the East Branch of the Croton through two 48-inch pipes. At the outlet of these pipes the water is discharged through a fountain vertically with a view of aerating it.

55. The Amawalk Reservoir is now being constructed on the Muscoot River, in the Croton Watershed, for the Department of Public Works, by Mr. John McQuade, contractor. Ground was broken in December, 1889. The reservoir will have an area of about 600 acres, and a storage capacity of about 5,200,000,000 U. S. gallons.

The reservoir is to be formed by an earthen dam, having a masonry core wall. The maximum height of the dam will be about 84 ft. above the surface of the ground.

56. Shows the setting of the reducers which form the inlet of the discharge-pipes.

57 and 58. Illustrate the construction of the Titicus Dam, which is now being built for the Aqueduct Commissioners by Washburn, Shaler & Washburn, contractors. The main part of the dam is to be a masonry structure, 534 ft. long, its maximum height

above the foundation being 135 ft. The masonry dam is continued on both sides by earthen dams, with masonry core-walls having a total length of 966 ft. The maximum height of the earth dam will be 102 ft. above the surface.

The reservoir formed by the Titicus Dam will have a storage capacity of about 6,000,000,000 U. S. gallons.

57*a*. Shows the timber flume by means of which the Titicus River was led around the excavation trench, and also some of the masonry-work.

57*b*. A view from the Southwest, taken November 1st, 1892, showing the main masonry dam, the north core-wall, the north embankment, and the paving, steam-shovel, etc.

58*a*. A view from the North, taken April 1st, 1893, shows part of the north core-wall, the main dam, and the "sheeted" trench for the south core-wall.

58*b*. A view of the front of the masonry wall, taken recently.

59*a*. Core-wall for the auxiliary Earth Dam of the Carmel Reservoir.

This reservoir will have an area of 998 acres and a storage capacity of 9,000,000,000 U. S. gallons.

59*b*. The timber flume of the Carmel Dam which leads the river around the foundation trench.

THE CROTON WATER-SHED.

THE CROTON WATER-SHED.

The Croton River, formed by the junction of three branches known as the East, Middle, and West Branch, rises in the southern part of Dutchess County, New York. After flowing through Putnam County in a southerly direction, the three branches join each other near the south boundary of said county, and form the Croton River, which flows through Westchester County in a southwesterly direction to the Hudson River, into which it empties at Croton Point, about 35 miles north of the lower part of the city of New York. The water-shed of the Croton, which is almost entirely in the State of New York, contains 339 square miles above the Old Croton Dam and about 360 square miles above the place where the New Croton Dam is being built.

The water-shed is very hilly. The rock principally found is gneiss. The surface soil consists generally of sand and gravel, and is very porous. The popula-

tion of the water-shed above the Old Croton Dam is estimated at about 20,000.

A number of the villages on the Croton River will soon have to be destroyed on account of the construction of the New Croton Reservoir.

60. Two of the lakes from which the city has drawn water.

61. Two views of Katonah, one of the villages which will have to be acquired almost entirely by the city of New York for the New Croton Reservoir, as the plans for the new water-works contemplate the purchase of a margin of about 250 feet around the new reservoirs. Katonah is situated on Cross River, a branch of the Croton, and has a population of about 500.

62. The village of Purdy's will also have to be almost entirely destroyed to make space for the New Croton Reservoir.

The condensed-milk factory, situated on the Titicus River, in the village of Purdy's, is one of the sources of pollution of the Croton water, and will soon be acquired by the City of New York.

63*a*. Croton Falls, a village near the junction of the East and West Branches of the Croton River. Part of the village will have to be acquired by the city of

New York, as it will be flooded by the New Croton Reservoir, and another portion to prevent the pollution of the Croton River by barns, etc., which have been built on the very edge of the river.

63b. Brewster is one of the largest places in the Croton water-shed, and a source of much pollution. The Department of Public Works of the city of New York is now erecting works to have the sewerage of the town purified by electrical precipitation, before being discharged into the Croton River.

64. A view of the Croton River at the village of Croton Falls, looking up-stream.

65. Shows a remarkable rock of blue granite, weighing about 60 tons, near the village of North Salem, in the Croton water-shed. It rests on three limestone rocks. As no blue granite of this kind is found nearer than Nova Scotia, this rock must have been brought to its present position by glacial action.

66a. A view of the Croton River, near its mouth, at the site of the proposed Quaker Bridge Dam. The project of constructing this dam has been abandoned for reasons not of an engineering nature. In its stead the New Croton Dam is now being built about 1⅛ miles further up stream.

66b. Shows the site of the New Croton Dam.

LITHOGRAPHS

FROM THE

REPORT OF THE AQUEDUCT COMMISSIONERS

OF JANUARY 1ST, 1887,

SHOWING SOME OF THE DETAILS OF
THE CONSTRUCTION OF THE
NEW CROTON AQUEDUCT.

NEW CROTON AQUEDUCT.

	Length in Miles.
Croton Lake to proposed Distributing Reservoir at Jerome Park	23.

This portion of the Aqueduct was constructed in tunnel, with the exception of 1.12 miles, excavated in open trench. The conduit was built according to "the horse-shoe cross-section," on a grade of 0.7 ft. to the mile, and is not "subjected to pressure" except in the siphon under Gould's Swamp.

Proposed Reservoir at Jerome Park to 135th Street Gate-house	6.83

This part of the Aqueduct is "subjected to pressure," and was therefore made circular. It was excavated entirely in tunnel.

Pipe-line from 135th Street Gate-house to Central Park Reservoir	2.37

Eight lines of 48-inch mains were laid for the new Aqueduct, but only four of these were laid to the Central Park Reservoir, the other four being connected directly to the Distributing Pipes.

Total length, Croton Lake to Central Park Reservoir	33.12

The total "fall" from Croton Lake to Central Park Reservoir is 34.39 feet.

From the inlet at Croton Lake to the proposed reservoir at Jerome Park the Aqueduct has a maximum discharging capacity of about 300,000,000 U. S. gallons per 24 hours, which is equal to that of a circular brick conduit having a diameter of 14 feet.

For convenience in excavating the tunnel, a "horseshoe section" was adopted instead of a circular one, as it afforded more room for the tracks, etc.

At Jerome Park the capacity of the Aqueduct was reduced to 250,000,000 U. S. gallons per 24 hours, which amount of water is conveyed to Manhattan Island, leaving 50,000,000 gallons for the Annexed District.

The diameter of the Aqueduct, from Jerome Park to the 135th Street Gate-house is 12 feet 3 inches, except for the tunnel under the Harlem River, where it was reduced to 10½ feet, to make the excavation as small as possible, in ground which the preliminary borings had shown to be treacherous.

67. Map showing routes of the Old and the New Croton Aqueduct, and of the Bronx River Conduit; also the Croton Water-shed and the proposed Quaker Bridge Reservoir. The project of building the

Quaker Bridge Dam has been abandoned; another dam, known as the New Croton Dam, is being constructed at present 1⅛ miles farther up-stream. (See Cards 95–99.)

68 and 69. The cross-sections of the Aqueduct at different points.

No iron lining was placed in the tunnel under the Harlem River, but about 200 lineal feet was used for the Aqueduct near Shaft 30. (See Card 36.)

70. Pocantico Blow-off and Waste Weir.

71. Blow-off and Waste Weir at Ardsley and at South Yonkers.

These Blow-offs are all constructed on the same general plan.

At each a waste weir is constructed at right angles to the line of the Aqueduct. By means of stop-planks placed on the weirs the depth of the water flowing in the Aqueduct can be regulated.

To empty a section of the Aqueduct between two of the blow-off gate-houses, for the purposes of inspection, repair, etc., stop-planks are dropped across the line of the conduit, in the grooves cut in the masonry of the side walls and of the central piers, which divide the water at these gate-houses into two streams in

order to reduce the length of the span of the stop-planks.

After dams have been formed at each end of the section of the Aqueduct which is to be emptied by means of the stop-planks, the blow-off sluice-gates are opened, and the water from the Aqueduct emptied into a stream near the gate-house.

72, 73, and 74. Construction of Shafts, "under pressure" and "not under pressure." About 40 shafts were sunk for the construction of the New Aqueduct. Some of these served only for temporary purposes and were filled up, either with masonry or dry filling, or with both.

The manner in which the permanent shafts through which the tunnel can be entered were finished is shown on Cards 72–75.

75. Shaft 25, the largest and deepest shaft on the New Aqueduct, was sunk on a bluff on the west side of the Harlem River. It was excavated 16½ feet by 33 feet inside of the timbers, and sunk to a depth of 426 feet. The tunnel under the Harlem River was driven entirely from the bottom of this shaft. This tunnel was started at an elevation of about 150 feet below high-water. After it had been driven 300 feet a pocket of quicksand and decomposed rock was

encountered, which made it necessary to sink Shaft 25 deeper, and to construct the tunnel about 300 feet below high-water.

Shaft 25 was built up so as to contain two masonry wells 12 feet 3 inches in diameter. The north well forms part of the Aqueduct; the south well is used for pumping out the siphon under the Harlem River, whenever it may be necessary for inspection or repairs. The pumping is done by means of two iron buckets 4 feet in diameter and 14 feet high, each containing 1300 gallons, which are raised and lowered alternately by a powerful steam-engine, which is placed in the permanent masonry head-house at the top of the shaft. The buckets empty their contents automatically into the blow-off pipes.

Shaft 25 is provided with two 48-inch blow-off pipes, which were placed in a drift and surrounded with masonry. They serve to empty the Aqueduct "under pressure" (Jerome Park to 135th Street Gate-house) into the Harlem River. Each blow-off pipe is closed by two 48-inch stop-cocks, which are placed in a small gate-house. (See Card 33.)

As the water in Shaft 25 is under such a pressure that it would rise 40 feet above the surface of the ground if not confined, the top of Shaft 25 was

securely closed by a double set of heavy manhole covers. The pump-well has a lining of cast-iron rings, 1¼ to 1½ inches thick (see Card 32), from top to bottom. The Aqueduct well has an iron lining only for a certain height near high-water, where the rock was seamy.

76a. Shows the Masonry Head-house and the Blow-off of Shaft 25, looking from the river.

76b. Shaft 26, the point of overflow on Manhattan Island. The shaft is 12 feet 3 inches in diameter. At its top an overflow-weir is constructed, the height of which can be regulated by means of stop-planks. Whenever the water rises above the top of the overflow-weir, it is discharged into the Harlem River through two 48-inch overflow-pipes.

A brick vault is built over the top of the shaft.

77, 78, and 79. New Inlet Gate-house at Croton Lake.

This structure was constructed for the new reservoir, which will be formed by the New Croton Dam, and will have its surface 27 feet higher than that of the present Croton Lake. Until the new reservoir has been constructed water can only be let into the new gate-house through the "By Pass."

When the new reservoir has been formed water can

be drawn into the gate-house through five different channels. By changing occasionally the inlet from one to the other a circulation will be created in the reservoir.

As the surface of the reservoir will be about 54 feet above the invert of the outlet of the gate-house, and as the Aqueduct for the first 24 miles is not to be subjected to pressure, the head of the water is overcome by a series of three sets of sluice-gates, placed in the cross-walls of the gate-house, which permit the water to flow into the Aqueduct "without pressure."

80 and 81. The 135th Street Gate-house receives the discharge of the Old and of the New Croton Aqueduct. Eight lines of 48-inch mains carry the new supply into the city, and four lines of 48-inch pipe connect with the old mains on 10th Avenue.

Each line of pipes starts from a small outlet-chamber, which can be separated from the main water-chamber of the gate-house by means of stop-planks placed in grooves cut in the masonry. The flow through each line of mains is controlled in the gate-house by a sluice-gate and by a stop-cock.

Either Aqueduct or both can be shut off from the gate-house by means of stop-planks.

82 and 83. The Central Park Gate-house, located at

the north end of the large reservoir in Central Park, forms the terminus of four of the eight lines of 48-inch mains which were laid in connection with the New Aqueduct. The outlet of each line of pipes is controlled by a sluice-gate. Grooves for stop-planks are cut in the masonry of the outlet-chamber of each pipe-line.

84*a*. Some of the appliances used by the engineers in staking out the axis of the tunnel on the surface and under ground, etc. The cross-sections of the tunnel excavation were obtained by means of a disk instrument, from which radial measurements were taken with a rod.

As the centre-line of the tunnel on the surface ran through valuable country-seats, etc., where trees could not be cut down, etc., wooden towers were built at certain points, to enable the transit men to sight over obstacles. By this means "offsets" on the line were avoided.

The iron plumb-bob shown for "dropping the wires" down a shaft was not used. A separate weight for each wire, placed in a bucket of water, was found to be preferable.

84*b*. Shows the kind of timber head-house, hoisting cage, and dump-car used on Shafts 1 to 11.